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NOAA HAB-OFS Newsletter

Welcome to the NOAA HAB-OFS Quarterly Newsletter. We are always happy to hear from you so please send your topic suggestions, questions, comments and feedback to hab@noaa.gov.

In this issue:

New Satellite Imagery Product for Texas HAB-OFS Bulletins

Satellite ocean color imagery is a key component of the HAB-OFS analysis. It is necessary for the early detection of *Karenia brevis* blooms in the Gulf of Mexico and for providing the observations of bloom transport necessary for forecast verification. Following extensive analysis, a new satellite imagery ensemble product will be incorporated into the HAB-OFS bulletins for Texas. The ensemble product is similar to the one that was transitioned for operational use in Florida following an evaluation which demonstrated that ensemble imagery improved *K. brevis* detection by over 70% as described in the June 2014 and June 2015 newsletters.

The primary source of ocean color imagery currently used by the HAB-OFS is derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua satellite, provided by NOAA's CoastWatch Program. To assist with *K. brevis* bloom identification, MODIS imagery is processed using a chlorophyll algorithm that highlights areas of anomalously high chlorophyll by comparing daily real-time chlorophyll to a 60 day running mean ending two weeks prior to the present (Stumpf et al., 2003). Since *K. brevis* blooms tend to be mono-specific once they are established, the chlorophyll anomaly product is an effective tool for identifying regions of high chlorophyll created by the blooms. Yet, the chlorophyll anomaly product is not specific to *K. brevis* and may also highlight areas of high chlorophyll associated with blooms of other phytoplankton species as well as benthic algae and sediments that are resuspended in the water column by wind and wave action. The Texas coast is prone to such resuspension events so *K. brevis* blooms can be difficult to discern in imagery. In an attempt to reduce false positives in imagery, a revised chlorophyll anomaly product is currently used that subtracts an estimate of the resuspended chlorophyll from the chlorophyll anomaly. However, false positives are still common when using the revised product (Kavanaugh, Derner, Davis, & Urízar, 2015).

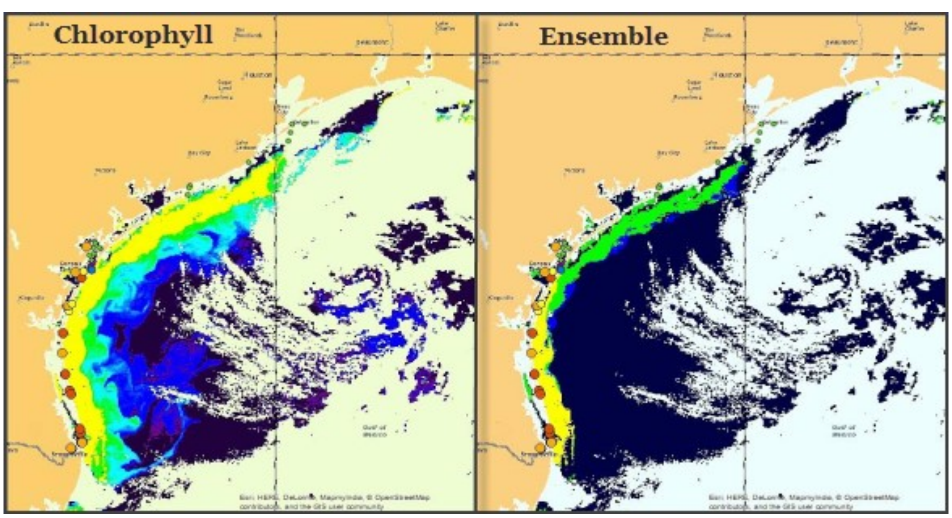

Figure 1. *(left) Anomalously high chlorophyll in yellow. (right) Ensemble imagery in yellow indicating the high chlorophyll area that matches the optical characteristics of K. brevis.*

The new Texas ensemble imagery product combines the revised chlorophyll anomaly algorithm with algorithms that specifically target the optical characteristics of *K. brevis*. One of the algorithms selected accounts for the relative particulate backscatter of blooms (Cannizzaro et al., 2008) and the other looks at how *K. brevis* blooms change the spectral shape characteristics in the blue wavelengths (at 490 nm) (Tomlinson et al., 2009).

A comparative analysis of the current revised chlorophyll anomaly product and the ensemble product was performed using a sample set of images from the Texas coast from September through December 2015. *K. brevis* water samples were overlaid on imagery to compare how

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well each algorithm performed at bloom detection. Results from the evaluation indicated that the Texas ensemble imagery would be a beneficial addition to the operational HAB bulletins. The ensemble products decreased false positives along the Texas coast and refined the spatial extent that is flagged, resulting in a 90% improvement over the revised chlorophyll anomaly product that is currently used.

These results are currently being reviewed by CO-OPS and, with approval, the Texas ensemble imagery products will be incorporated into future HAB-OFS bulletins. When the transition to operations is completed, an updated bulletin guide, including information about how to interpret ensemble imagery, will be sent to all bulletin subscribers.

References:

Cannizzaro, J., Carder, K., Chen, F., Heil, C., Vargo, G. (2008). A novel technique for detection of the toxic dinoflagellate *Karenia brevis* in the Gulf of Mexico from remotely sensed ocean color data. *Continental Shelf Research*, 28, 137-158.

Kavanaugh, K., Derner, K., Davis, E., Urízar, C. (2015). *Assessment of the western Gulf of Mexico Harmful Algal Bloom Operational Forecast System (GOMX HAB-OFS): An Analysis of Forecast Skill and Utilization from October 1, 2010 to April 30, 2014.* NOAA Technical Report. NOS CO-OPS 080.

Stumpf, R., Culver, M., Tester, P., Tomlinson, M., Kirkpatrick, G., Pederson, B., Truby, E., Ransibrahmanakul, V., Soracco, M. (2003). Monitoring *Karenia brevis* blooms in the Gulf of Mexico using satellite ocean color imagery and other data. Harmful Algae, 147-160.

Tomlinson, M. C., Wynne, T. T., & Stumpf, R. P. (2009). An evaluation of remote sensing techniques for enhanced detection of the toxic dinoflagellate, *Karenia brevis*. *Remote Sensing of Environment*, 113, 598-609.

Potential for Bloom Formation at the Coast: What Does It All Mean?

You may have noticed a forecast for the potential for bloom formation at the coast included in our southwest Florida bulletins preceding the blooms.

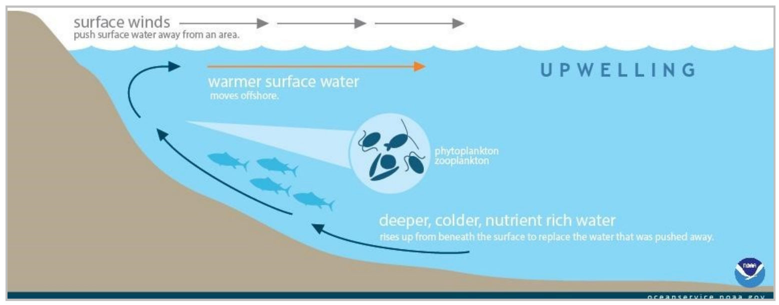

Figure 2. *Offshore winds push the surface water away from the coast, causing water from the deeper ocean to rise and take its place at the surface.*

The forecast for bloom formation at the coast is included in every bulletin when we are not actively monitoring a *K. brevis* bloom. So, what is the basis of the forecast? First of all, it is based on the season. *K. brevis* blooms typically form between August and late December (Stumpf et al., 2003). Secondly, it is based on the wind conditions. When the wind blows across the surface of the ocean, it forces the water to move. The net motion of the surface layer of the ocean (up to about 100 meters) is 90-degrees to the right of the wind direction, with the water immediately at the surface moving 45-degrees to the right and so on—a phenomena known as "Ekman transport". During bloom season in southwest Florida, for instance, winds from the north to east cause surface water at the beach to begin moving offshore. The displacement of surface water moving offshore causes deep water from below to be pulled upwards and towards the coast—THIS "upwelling" is what the HAB team is on the lookout for.

K. brevis develops blooms offshore in deep water where our satellite imagery can't spot it. However, when a bloom has formed and strong winds blow at an offshore angle for 2-3 days at a time, upwelling can bring *K. brevis* cells up from the deep to the surface where they might show up on our satellite imagery (Stumpf et al., 2003). When that's the case, you'll see the final sentence of our analysis section of the Florida bulletin look something like: "Wind conditions are favorable for upwelling today through Thursday, increasing the potential for *K. brevis* bloom formation at the coast later this week." We've even modified the wind diagram on our bulletin so that upwelling favorable winds appear as red arrows (see Figure 3).

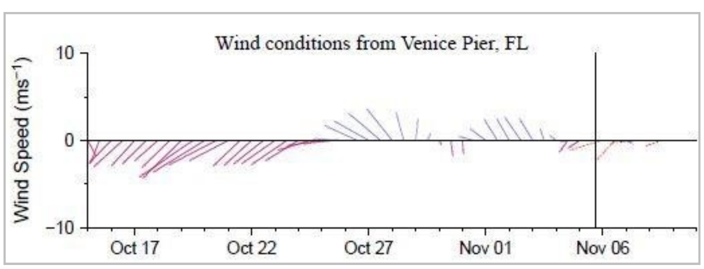

Figure 3. *Red barbs indicate upwelling favorable winds.*

It's not so much a prediction that a bloom of *K. brevis* is going to form, but a statement saying that if a *K. brevis* bloom has developed offshore, conditions will be present that may bring that bloom to the coast. According to modeling research, different hydrodynamics seem to be responsible for transporting blooms to the Texas coast and more work will need to be done before the HAB team can provide a forecast there (https://coastalscience.noaa.gov/news/habs/origin-toxic-red-tides-texas-identified/). Next time you're wondering if a *K. brevis* might show up along the southwest Florida coast, check out our bulletin.

References:

Stumpf, R., Culver, M., Tester, P., Tomlinson, M., Kirkpatrick, G., Pederson, B., Truby, E., Ransibrahmanakul, V., Soracco, M. (2003). Monitoring Karenia brevis blooms in the Gulf of Mexico using satellite ocean color imagery and other data. Harmful Algae, 147-160.

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Sampling the *Cochlodinium polykrikoides* Bloom in the York River

Figure 4. *C. polykrikoides bloom in the York River, VA (Credit: VIMS).*

In an effort to better characterize Chesapeake Bay algal blooms from space, scientists from the National Centers for Coastal Ocean Science (NCCOS) are collecting above water radiometry for algorithm development. On August 15, 2016 they participated in a sampling effort conducted by Virginia Institute of Marine Science (VIMS) researchers, who are responding to a bloom of *Cochlodinium polykrikoides* and *Alexandrium monilatum* along a large stretch of the York River in Virginia (Figure 4). Both species have bloomed almost annually for decades in the York River region and other locations within the bay. *C. polykrikoides* blooms are cause for concern as they have been implicated in juvenile fish and shellfish mortality and are widely known to cause fishery impacts in Asia and other locations globally. *A. monilatum* has also been associated with mortality of marine finfish and invertebrates in the Gulf of Mexico and more recently, mortalities of oysters and their larvae in the Chesapeake Bay. To better assess the impacts of these blooms on oysters and oyster aquaculture in the Chesapeake Bay, the NCCOS HAB Event Response Program approved a small project supporting VIMS and a Virginia commercial oyster grower to examine HAB impacts during active blooms.

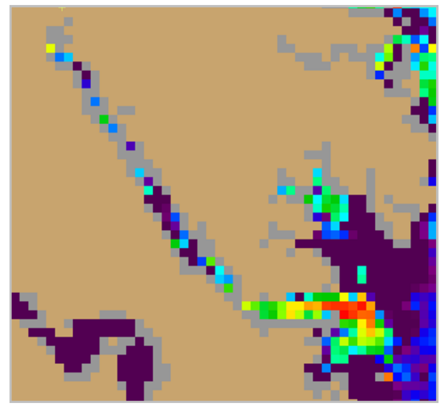

Figure 5. *MODIS Aqua Red Band Difference (RBD) image of the York River, Virginia. Red to green colors indicate the location of the C. polykrikoides bloom.*

Satellite remote detection is necessary to provide a more extensive and timely detection and monitoring system. Hand-held radiometry, a measurement used to compare with satellite imagery and improve algorithm development, was collected simultaneously with water samples for pigment and phytoplankton measurements. These data will be used for the development of better satellite ocean color detection. A Red-Band Difference (RBD) algorithm developed by Amin et al. (2009), for the detection of *K. brevis* in Florida shows promise in detecting these blooms (Figure 5). When applied to MODIS imagery, the RBD seemed to accurately identify the extent of the blooms in the York River. In addition, RBD image products have been provided to Maryland Department of Natural Resources for the monitoring of other high biomass blooms associated with low dissolved oxygen events. The algorithms detect high biomass, fluorescing algae, and although they are not species specific, they may aid in determining bloom extent and can guide sampling efforts.

HAB Team Begins Monitoring Blooms in Texas and Florida

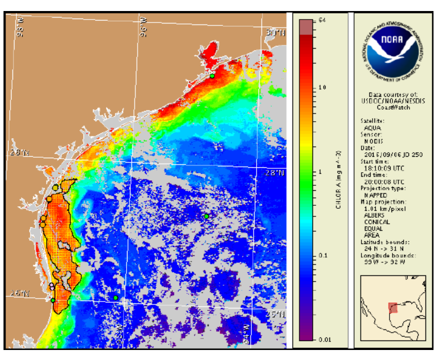

Figure 6. *A K. brevis bloom visible in MODIS Aqua imagery.*

After increasing *K. brevis* concentrations were detected by Texas A&M University's Imaging FlowCytobot at the Port Aransas pier, the Texas Parks and Wildlife Department and partners began collecting additional water samples which led to the confirmation of a bloom. The HAB team started issuing twice weekly bulletins to aid in response efforts. *K. brevis* is present in patches along the coast of Texas from Aransas Pass to south of the Rio Grande and within the lower Laguna Madre Bay. Respiratory irritation, discolored water, and fish kills have been reported where the bloom is most dense.

A week after the bloom was confirmed in Texas, a separate bloom was confirmed in Sarasota County from water samples received from Mote Marine Laboratory, the Florida Fish and Wildlife Conservation Commission and partners. Since then there have been reports of respiratory irritation and dead fish from Pinellas to Lee counties. The HAB team is now issuing twice weekly bulletins.

Many Thanks to our Partners and Data Providers

http://tidesandcurrents.noaa.gov/hab/contributors.html

This newsletter was written and designed by:

NOAA/National Ocean Service

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